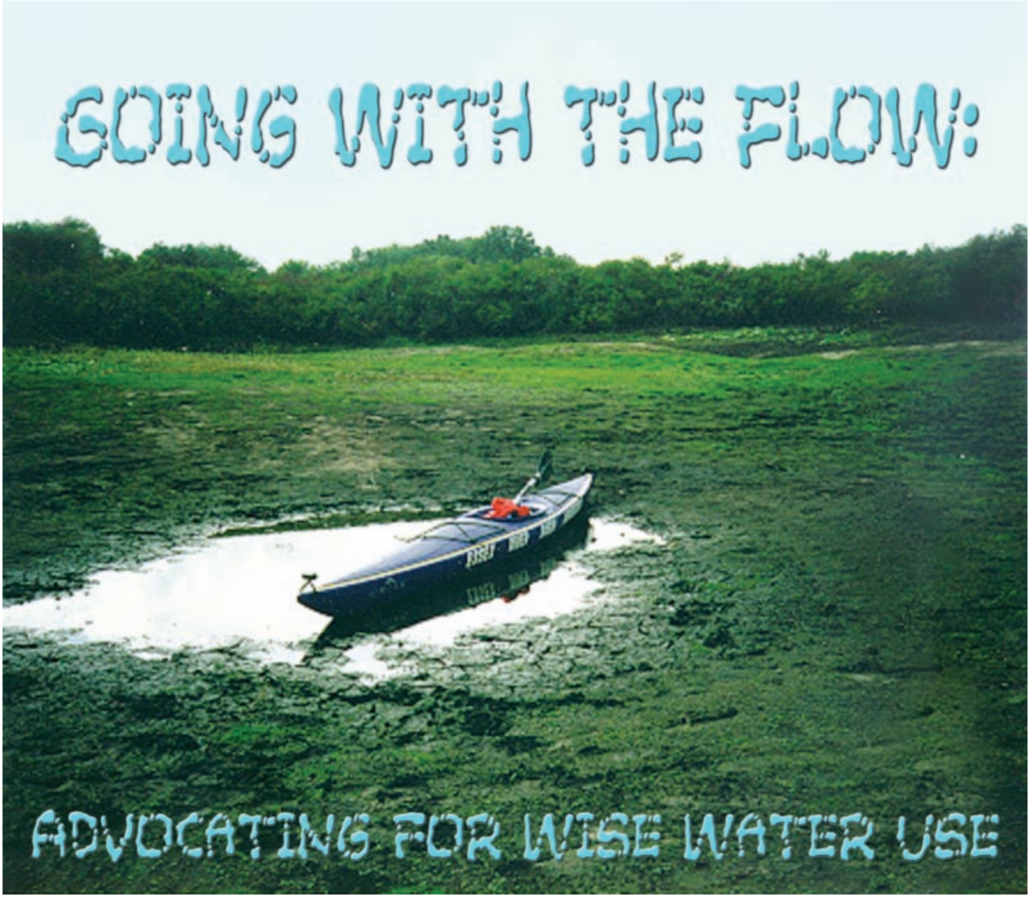


Photo © by Kerry Mackin

by Gabrielle Stebbins

When a river such as the Ipswich dries up like this, too much water is being withdrawn from the surrounding aquifer. Environmental and recreational values suffer, and the negative effects on aquatic and wetland species are enormous.

Is there a water ban in your community? Are you limited in the number of days you are allowed to water your lawn? Do you stare at "water restriction" signs in wonderment as torrential rainstorms deluge your town in floods? During an early morning stroll through nearby conservation land, have you stepped across a dry streambed or found a fishkill?

Massachusetts' legacy of 11,000 miles of streams and rivers and an average of 45 inches of rain per year has led to our state being identified as "water rich." However, though the rain continues to pour, and while climate change is predicted to deliver more rain upon the Northeast region, Massachusetts' water supplies are dwindling, and with them, healthy aquatic habitat. There are three primary causes: increased impervious surfaces; excessive water use in summer; and the exportation of water "out of basin." There are multiple solutions, most of which require citizen awareness and the will to facilitate local change.

Why does it matter when our rivers run dry?

Our 11,000-plus miles of flowing water are merely extensions of our underground aquifer; 80% of a river's flow is groundwater revealing itself above land. These waters form Massachusetts' 27 watersheds, a watershed being "the region draining into a river or other body of water." The boundaries of our watersheds are our mountain ranges and hilltops — the high land that determines which way the water will flow when it falls to the earth. Unlike water falling into the confined aquifers in some areas of the western U.S., every drop of rain that falls in our watersheds will eventually run into a stream, lake or estuary.

Rivers and streams have seasonal patterns of high and low flow, or "flow regimes"; generally rivers experience the greatest amount of flow in spring, when "April showers bring May flowers" and snow begins to melt but vegetation has not "leafed out" (which releases water back into the sky through evapo-transpiration). As the weather warms, water levels in rivers naturally drop, while lush plant growth increases evapo-transpiration. Lowest stream flows occur in late summer and early fall. As the temperatures cool into winter and plant growth and evapo-transpiration decrease, water levels increase somewhat.

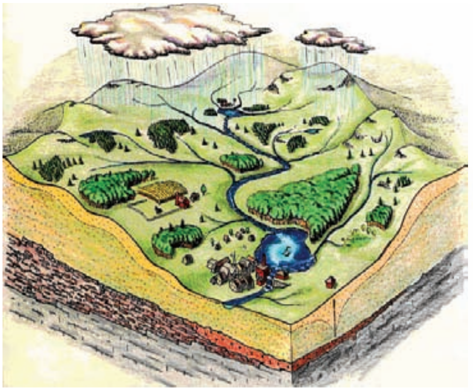
The dynamic annual flow pattern is crucial to river ecosystems. Altering the flow regime can impair or destroy the physical habitats of the river channel and floodplain (e.g. flash floods scouring out the sides of river banks and depositing sediment downstream, often smothering aquatic habitat such as fish nests). It can also confuse aquatic species by sending inaccurate timing signals for reproduction and other lifecycle needs; fragment rivers into multiple standing pools rather than one flowing system (preventing aquatic species from moving to other areas for protection, reproduction, food); and it can threaten native species by allowing nonnative, invasive species to colonize new areas and damage or destroy crucial habitats.

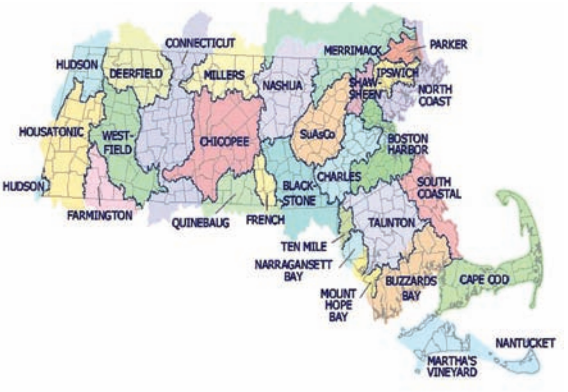
Any avid fisherman will tell you that salmon and trout dislike warm water. As stream levels drop, becoming shallower and narrower, the shade provided by riverbank trees reaches less of the water, and the sun warms the remaining water more quickly. Warm water holds less dissolved oxygen than cold water, so aquatic life that depends on cool, flowing, well-oxygenated water, becomes stressed and may search for alternative habitat or die.

Challenge #1: Impervious Surfaces

The nature and extent of human development in a watershed strongly influences the condition of local water resources. For example, in a relatively undeveloped area like the Fox Den Wildlife Management Area in the town of Worthington, just over a third of the rainwater will recharge into the underground aquifer, while a similar amount will return to the atmosphere through evaporation and transpiration. A quarter of the rain will seep into the top layers of the earth and gradually flow towards the nearest stream or pond. This is referred to as interflow. Less than 1% will become "overland flow" or "runoff" that travels quickly to the nearest water body.

Meanwhile, rainfall in a more developed, urbanized area (such as greater Boston, Worcester or Springfield) dominated by rooftops, roads, driveways, highways and parking lots, follows a very different path. Comparing the pie charts of the un-

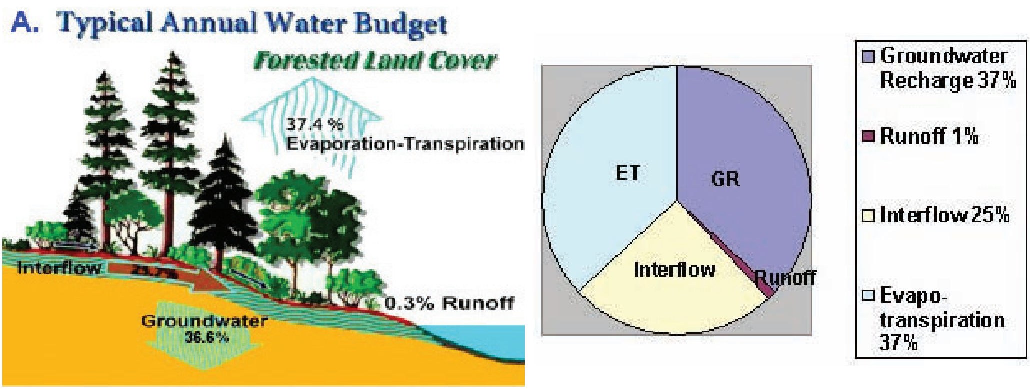




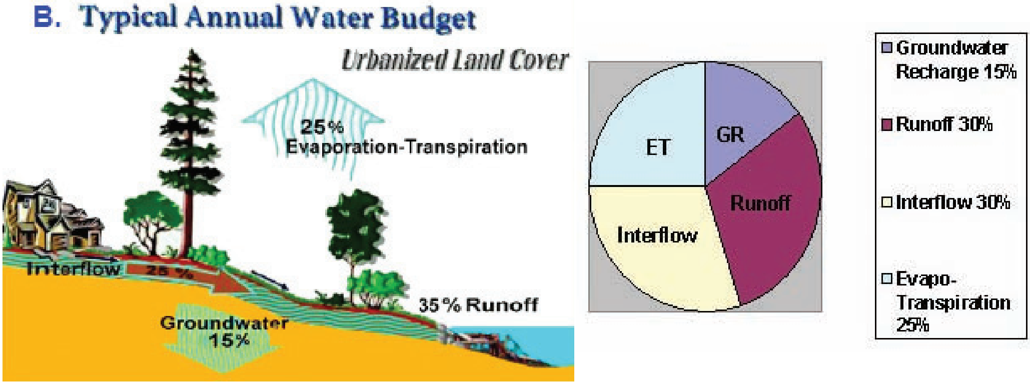
A depiction of a watershed, left, and Massachusetts' 27 watersheds, right.

developed to the developed watersheds is sobering: less than 1/6 of the rain that falls in the developed watershed will be absorbed into the ground, and runoff increases 30 times! While the specific runoff amounts vary slightly depending on soil type, slope, and other watershed specifics, the end result is the same: when it rains in developed areas, we are not refilling our cup. Instead of rain slowly seeping into our aquifers, 1/3 of it runs off our parking lots and lawns, picking up fertilizer, grease particles, animal waste and other street delicacies, and flows quickly to the nearest storm drain through culverts and pipes to our nearest open water body. These increased storm flows not only pollute our rivers and cause flood damage, they also cause lower groundwater levels since the aquifer is not recharged. This in turn leads to reduced stream flows because the groundwater is not available to feed streams in summer. It's no surprise that 7 out of 12 of our native freshwater mussels (unpaid, natural water treatment filterers) now require protection under the Massachusetts Endangered Species Act.

Through our current development and construction practices, we clear 40 acres of open space each day in Massachusetts. That's about 30 football fields, including end zones. The result: a greatly altered hydrological cycle that increases flash flood events and decreases groundwater recharge, leaving our rivers and streams, and the life in them, subject to extreme and potentially catastrophic changes that would rarely occur under natural conditions.



Impervious surfaces (paved roads, rooftops and parking lots) in developed areas (below) have a profound effect of on the movement of water: runoff in such areas is 30 times greater than in undeveloped forested habitat (above), causing pollution and flooding, and robbing groundwater supplies of recharge.



Mussels by Jay Cordeiro; Inset, Top, by Pine Dubois; Inset. Bottom: courtesy Connecticut DEP

When a permanent stream goes dry, its fish (small inset) and invertebrates (such as freshwater mussels, above) will perish, leaving an impoverished system. Even when streams aren't bled dry, a significant reduction in flow can cause major mortalities, prevent fish such as white sucker (large inset) and trout from reaching feeding, spawning and refuge areas, and severely disrupt the aquatic community.

Challenge #2: Summer Water Demand

Simultaneously, though Massachusetts has experienced a net loss in human population in recent years, we are consuming more water in the Commonwealth. So not only are we not refilling our cup, we are putting in more straws! Across the state, municipal water departments are struggling to identify new water sources to meet increasing demand. For the majority of communities, the crisis of being "water short" occurs primarily in summer. From June through September, residential water demand frequently increases as much as 50%. In some towns it skyrockets 200-400%! This increase is not due to a vast surge in drinking, washing or cooking needs. This is for our lawns.

Unfortunately, our increased water demand coincides with nature's "low flow" period. So as rivers naturally decrease in water volume, we begin slurping through our straws all the more. This poses several challenges to water suppliers as well as aquatic life. Our insatiable desire to water our lawns is a major motivator for costly water system expansion. If water rates increase, customers put in private wells (which still affect groundwater levels). If efforts to increase conservation succeed, overall revenue decreases unless rates are increased. Also, as water becomes less plentiful underground, well pumps must work harder to draw water from the ground, resulting in greater energy use and the need for more infrastructure maintenance and repair.

Danforth Brook, Acton, in (left to right) late winter and spring, above, and early summer and late summer, below. Our highest stream flows typically occur in spring due to snow melt and minimal evapo-transpiration; lowest occur in late summer when natural and unnatural withdrawls are highest and human demands are greatest (mostly for watering lawns composed of non-native grasses.)

Photos by Organization for the Assabet River

As consumers, we are radically inconsistent with our spending patterns. We don't mind buying bottled water at $9.45 per gallon (for some of the pricier brands), but we take issue if our town water department increases the cost of tap water from $0.003 per gallon to $.025 per gallon. For the convenience, and for some who don't realize how clean tap water is, consumers are comfortable with paying 3000 times more for commercial bottled water than, say, for the City of Greenfield's water, even though quality and purity are essentially identical. Maybe people would change their water buying habits a little if they pictured each container of bottled water about a quarter full of crude oil. That is roughly what the energy costs are for production, shipping and eventual disposal/recycling of every bottle.

Challenge #3: Interbasin Transfers

In the 1920s it became apparent that eastern Massachusetts would not have enough water to support further growth. As a result, the central Massachusetts' towns of Dana, Enfield, Greenwich and Prescott were "discontinued" — razed and flooded with water from the Swift River to create the Quabbin Reservoir, now operated and managed by the Massachusetts Water Resources Authority (MWRA). The MWRA supplies about 220 million gallons of water per day to local water departments in 47 towns including Boston. It meets the water use needs (both essential and non-essential) of 2.2 million people and 5,500 industrial users at the expense of four towns and the Swift River.

The forethought of our predecessors has been crucial to Massachusetts' growth, and for many, the Quabbin area is a great recreational benefit. However, in the long run, taking water from one watershed and discharging it in another (in the case of the MWRA Deer Island Treatment Plant, the discharge is several miles off the Boston shoreline) results in a net loss of water from the local watershed. Besides the overall effect the MWRA system has on the Swift River in the Chicopee basin, for communities such as Natick and Walpole that only use MWRA for sewer services, water is withdrawn from the local basin (the Sudbury and the Neponset basins, respectively), but sewered "out of basin" to Deer Island. The practice of transferring water out of basin has the potential to cause so many ecological problems that one of the basic premises of the Massachusetts Water Policy is to "keep water local". (To download a copy of this comprehensive policy, visit **www.mass.gov/envir/wptf/publications/mass_water_policy_2004.pdf**.)

These three challenges — increased impervious surfaces (loss of groundwater recharge), wasteful water use during nature's driest months, and transferring water out of local basins — leave us with streams that do not glisten nor rustle. We are left with dead fish, fewer sensitive species like slimy sculpin, reduced water quality (less water means less dilution of stormwater runoff), reduced recreational opportunities and aesthetic benefits, higher water rates, and a further degraded planet to pass on to our children.

Solutions

Fortunately, there are multiple solutions. The first is to focus hard on the demand side of the equation and get everyone to recognize that nothing is free. The public must be educated regarding the true cost of water, the implications of maintaining an acre of Kentucky bluegrass lawn, and the many alternative landscaping approaches that require minimal water. Along those lines we can restructure water rates (an increasing block structure allows for human water needs to be met, while charging larger water users more for their greater consumption), and we can offer rewards (rebates) to consumers who purchase and use water efficient appliances and conservation devices like rain barrels that collect roof runoff for later yard use.

If people insist on using irrigation or automatic watering systems to maintain artificial landscaping, then we should require them to install smart systems that include a soil moisture sensor so water is only used as needed. We should encourage towns to pass bylaws that increase open space protection, limit outdoor watering days and lawn size (discouraging non-essential use), and incorporate landscaping design features such as permeable pavement and bioretention systems like rain gardens (referred to as low impact designs) that actively send water into the ground to recharge aquifers. Finally, we can decrease "unaccounted for water" lost through pipe leaks through inspection and repair of our distribution systems.

Focusing on the supply side, there are also options, though not as plentiful and considerably more costly. These might include exploration to identify a "new source" of water in your town (for example, digging a new well in an untapped aquifer) and/or increasing groundwater recharge through stormwater retrofits that slow the flow of stormwater so infiltration can occur. For some towns, joining the MWRA, though not a long term, sustainable solution, might be a short cut remedy to their specific water shortage problems. Other possibilities include the practice of water reuse, (such as using treated wastewater for golf course irrigation), injecting treated wastewater into natural or artificial aquifers underground, or even desalinizing ocean water.

Using Natural Resources Wisely

Many communities are involved, to varying degrees, with the multiple solutions mentioned above. However, though we are neither the Middle East nor the southwestern United States, Massachusetts will soon have at least one desalination plant. After several years of negotiations with environmentalists, state and federal agencies, the private company Aquaria Water has succeeded in obtaining approval for a $40 million plant to withdraw and discharge water from the Taunton River estuary (not including $22 million for piping) to produce freshwater through the process of reverse osmosis.

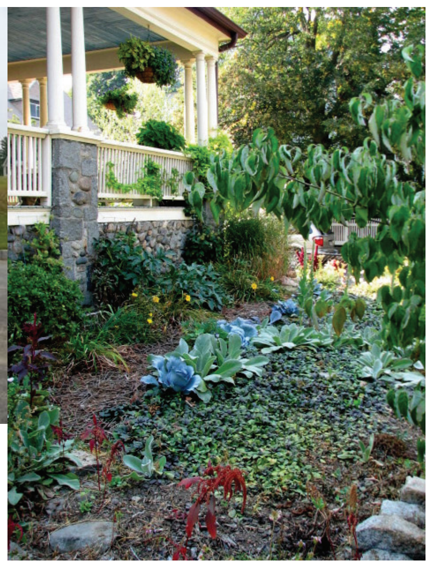
Concerns with reverse osmosis typically involve the impact it has on aquatic animals, including entrainment and impingement of aquatic species on the water intake screens, increased brine concentration at the discharge locations, and lower water levels in the source area. Another major concern with reverse osmosis is that it requires extensive energy. A 2003 report by the U.S. Department of Interior's Bureau of Reclamation estimates that construction of a desalination plant costs seven to eight times that of a conventional freshwater treatment plant, and the water treatment costs five to six times that of conventional treatment largely due to energy needs. Technology has improved since 1980, but over 60% of the current cost is still energy-related, and further improvements are not expected.

While the Aquaria desalination project has been under negotiation for over a decade, it is not in keeping with current concerns. Governor Patrick's "Sustainable Development Principles" propose that we "make efficient decisions"; "protect land and ecosystems"; and "use natural resources wisely." From the local to the state and federal level, there is considerable discussion about lessening America's reliance on fossil fuels. In a state that receives just under four feet of water a year, a careful assessment of the economic, ecological and energy impacts of desalination, as compared to an integrated approach to water management, is imperative.

Conclusion

My inspiration for writing this article has come from hours of standing in depleted streams and the nagging sensation that the greater public, as the consumer, should be part of the solution. Why are we willing to pay more to buy bottled water that follows less stringent water quality standards than our own tap water but requires extensive energy to transport and bottle when we won't support our local water department increasing the water rates? Why is our concept of household property aesthetics so rigid that we must have a nonnative grass with minimal root depth dominate our landscape and guzzle our water supply? Why do we accept mainstem rivers, such as the Ipswich River, running dry only to become a hiking trail? (While a hiking trail is nice, wouldn't habitat for prize trout be better?) Why is all of this acceptable when there are solutions?

We're coming to a watershed moment. What will we decide? Who gets to decide? Will we bicker over every nuance, every subtlety, while our streams are desiccated but our lawns, many covered in pesticides and herbicides, flourish green and true?



House Photo by Michelle Walsh; Garden Photo by Author

Simply adjusting our landscaping aesthetics by replacing exotic, high maintenance grasses with native, drought-tolerant plants (right) would help control increased summer water demands.

Photo © by Bill Byrne

A MassWildlife fisheries research crew electro-samples a brook in late spring. Native brook trout and other species requiring cold, well oxygenated habitat can be easily extirpated if they cannot find adequate refuge during low water periods.

Across the board, current environmental challenges are being exponentially exacerbated by the actions of countless individuals who (frequently unknowingly) impair nature's capacity to handle our demands for more: more water, more land, more energy. In many arenas, such as climate change, changing our individual actions have an effect, but the global, mass nature of the challenge means that most likely we will not see this incremental positive change at the local level.

To the contrary, our water resource challenge is something that we *can* drastically improve at the local level. While an increasing population may eventually outstrip our local aquifers of their water supply, our current challenges are amenable. Change our approach to development, expand our notion of a beautiful landscape, minimize interbasin water transfers and address traditional infrastructure that throws stormwater away, we will abate the Massachusetts water resource issue — at least for now.

Photo by Margaret Kearns

How can you enact this change? Recognize that our earth has finite resources, and be willing to make the changes and the sacrifices that recognition of this truth may require. Support your local water department. Let them know that the public wants wise resource management, and that you are willing to pay for it. Alter your landscaping preferences. Install water efficient appliances. Get involved in your local planning board or form a Stream Team with my assistance.

There are countless opportunities to become more involved in activities that protect and restore our rivers and streams which provide the lifeblood for the wildlife we enjoy, the fish we catch, and the integrity of our natural resources. If you'd like to learn more, visit **www.massriverways.org** or contact me at **Gabrielle.Stebbins@state.ma.us**.

Gabrielle Stebbins first fell in love with nature at the late age of 23 while camping in the Serengeti. She holds a Masters degree in Sustainable Development Policy and is also a professional violinist. She would like to thank MK, CD, BM & AH for their help in editing this article.